





 SAN FRANCISCO

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Global Aging and Health

Bridging Science, Policy, and Practice

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Health-Assistive Smart Homes with a Clinician-in-the-Loop

Concurrent Scientific Sessions VII

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This Continuing Education activity is jointly provided by The Annenberg Center for Health Sciences at Eisenhower and The Gerontological Society of America.

CO-HOST ORGANIZATIONS





DISCLOSURE(S)

Research Support:

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Consultant:

None

**Discussion of Off-Label,
Investigational, or
Experimental Drug Use:**

None



Situating the Research





CASAS

Health-Assistive Smart Home

1. A home that can perceive its environment through the use of sensors, and can act upon the environment through the use of actuators^{1,2}.
2. Uses machine learning to identify changes in health states^{3,4}.





Chronic Illness Study

Purpose:

Add a clinician-in-the-loop for development of a health-assistive smart home

Technology:

5 'Smart Home in a Box' (SHIBs) deployed

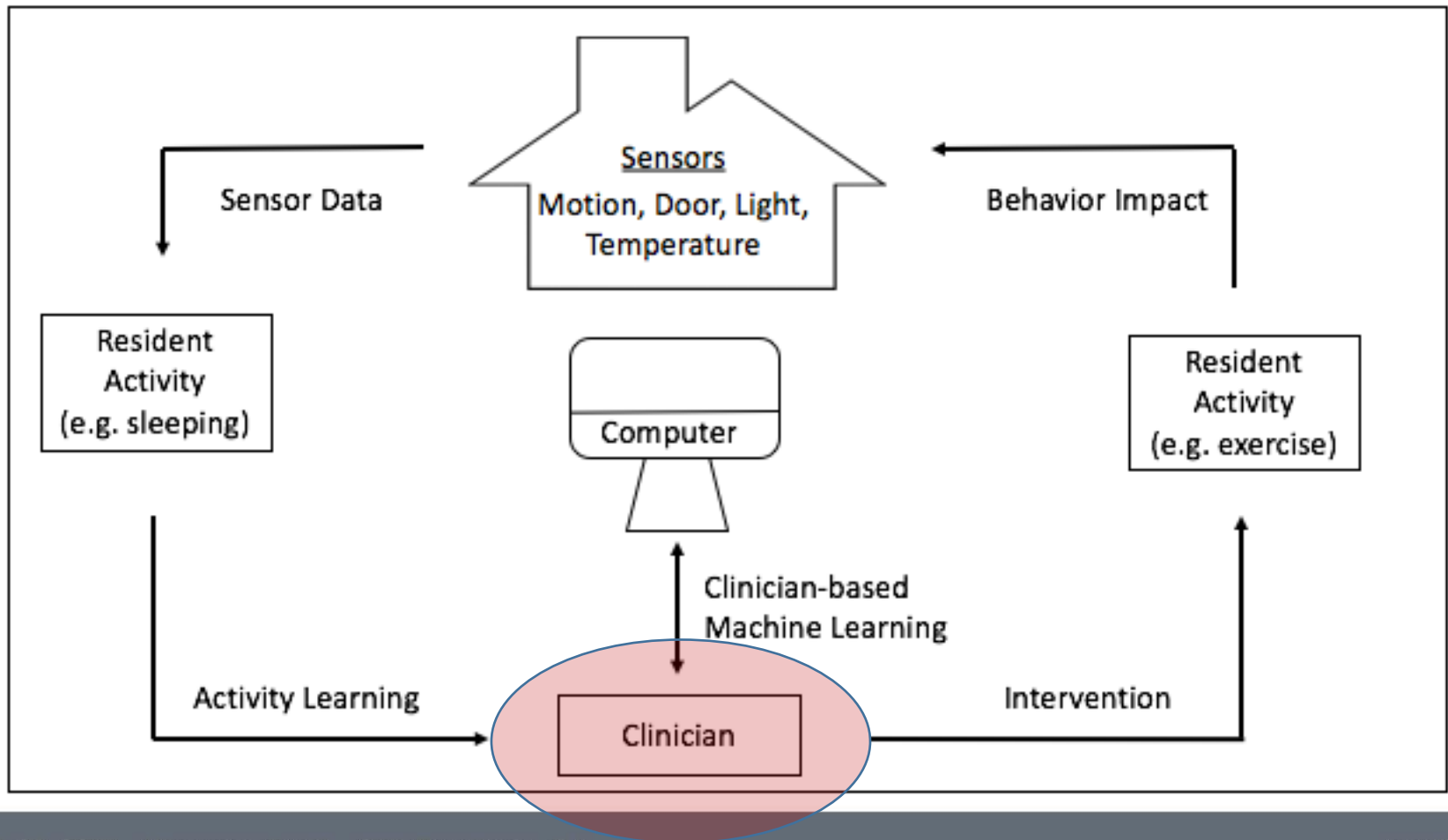
Inclusion Criteria

- 55 or over
- ≥ 2 Chronic Illness





Clinician-in-the-Loop





Clinician Process

- 1. Organize health information**
- 2. Identify measures in the literature**
- 3. Identify clinical change in health state**
- 4. Verify reliability of data**
- 5. Conduct scoped review of sensor data**
- 6. Provide clinical interpretation of sensor data to engineers**

Nurse provides clinical interpretation of data for training the machine⁵.



Clinical Interpretation: Qualitative Content Analysis in Quantitative Data

Qualitative Methods	Quantitative Data
Transcripts	Text-based data
Patterns	Motion patterns & daily routines
Themes	Clinically relevant repeated, or stand-out, motion patterns



Clinical Findings

34 total health events were observed and interpreted between November 2016 and June 2017; 18 falls

Wandering

Insomnia

Weakness

Nocturia

Situational Depression

Medication Side Effect

UTI

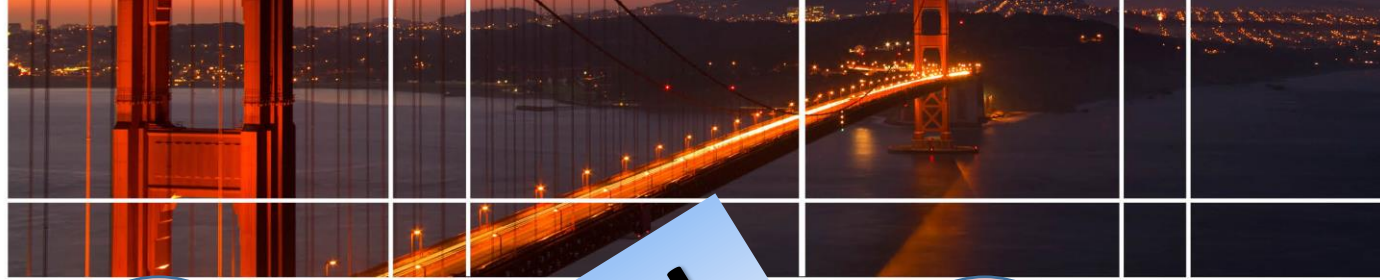


Fall #2



Fall #1





1st Fall

01:42:36.983159	KitchenAStove	OFF
01:42:42.797888	KitchenAStove	ON
01:42:43.920274	KitchenAStove	OFF
01:42:47.483751	KitchenAStove	ON
01:42:54.981957	KitchenAStove	OFF
01:42:59.107937	KitchenAStove	ON
01:43:04.542614	KitchenAStove	OFF
01:43:05.105334	KitchenAStove	ON
01:43:08.482623	KitchenAStove	OFF
01:43:09.420285	KitchenAStove	ON
01:43:11.292165	KitchenAStove	OFF
01:43:12.234052	KitchenAStove	ON
01:43:15.421041	KitchenAStove	OFF
01:43:18.041292	KitchenAStove	ON
01:43:21.977236	KitchenAStove	OFF
01:43:25.727567	KitchenAStove	ON
01:43:28.537520	KitchenAStove	OFF
01:43:51.040297	KitchenAStove	ON
01:43:52.162039	KitchenAStove	OFF
01:44:00.790745	KitchenAStove	ON
01:44:01.914290	KitchenAStove	OFF
01:44:35.286441	KitchenAStove	ON
01:44:36.412082	KitchenAStove	OFF
01:44:37.533890	KitchenAStove	ON
01:44:38.659852	KitchenAStove	OFF
01:44:51.782983	KitchenAStove	ON
01:44:54.783024	KitchenAStove	OFF
01:45:09.030771	KitchenAStove	ON
01:45:11.282722	KitchenAStove	OFF
01:45:14.282109	KitchenAStove	ON
01:45:15.408684	KitchenAStove	OFF
01:45:26.279474	KitchenAStove	ON
01:45:27.405054	KitchenAStove	OFF
01:45:56.841847	KitchenAStove	ON

2nd Fall

20:32:35.972543	BathroomASink	ON
20:32:37.099719	BathroomASink	OFF
20:32:41.975241	BathroomASink	ON
20:32:43.109241	BathroomASink	OFF
20:33:01.659677	BathroomASink	ON
20:33:02.797194	BathroomASink	OFF
20:33:28.311726	BathroomASink	ON
20:33:29.415047	BathroomASink	OFF
20:33:30.937983	BathroomASink	ON
20:33:32.031737	BathroomASink	OFF
20:33:34.096431	BathroomASink	ON
20:33:35.218466	BathroomASink	OFF
20:33:36.353327	BathroomASink	ON
20:33:37.469114	BathroomASink	OFF
20:33:41.605220	BathroomASink	ON
20:33:42.730727	BathroomASink	OFF
20:33:52.281363	BathroomASink	ON
20:33:53.403094	BathroomASink	OFF
20:33:55.656106	BathroomASink	ON
20:33:56.774775	BathroomASink	OFF
20:33:57.711272	BathroomASink	ON
20:33:58.839294	BathroomASink	OFF
20:33:59.778491	BathroomASink	ON
20:34:00.903390	BathroomASink	OFF
20:34:56.586383	BathroomASink	ON
20:34:57.713773	BathroomASink	OFF
20:36:11.018244	BathroomASink	ON
20:36:13.823285	BathroomASink	OFF
20:36:26.198673	BathroomASink	ON
20:36:30.517034	BathroomASink	OFF
20:37:03.329039	BathroomASink	ON
20:37:04.452180	BathroomASink	OFF
20:37:06.134768	BathroomASink	ON
20:37:07.260795	BathroomASink	OFF
20:37:07.820086	BathroomASink	ON
20:37:10.265053	BathroomASink	OFF
20:37:13.269480	BathroomASink	ON
20:37:17.384001	BathroomASink	OFF
20:37:24.706057	BathroomASink	ON
20:37:25.831310	BathroomASink	OFF



2017-05-26	21:01:34.695532	<u>LivingRoomArea</u>	OFF	
2017-05-26	21:04:44.232883	<u>LivingRoomArea</u>	ON	
2017-05-26	21:04:45.211312	<u>LivingRoomChair</u>	ON	
2017-05-26	21:04:45.470087	<u>KitchenADiningChair</u>	ON	
2017-05-26	21:04:46.337140	<u>LivingRoomChair</u>	OFF	
2017-05-26	21:04:46.590135	<u>KitchenADiningChair</u>	OFF	
2017-05-26	21:04:46.857620	<u>LivingRoomArea</u>	OFF	6 min gap in data here
2017-05-26	21:10:41.846734	<u>KitchenADiningChair</u>	ON	
2017-05-26	21:10:41.970689	<u>KitchenADiningChair</u>	OFF	



TIME

21:04:46.857620

and

21:10:41.846734



Restless Leg Syndrome

2017-01-15	01:42:05.037050	BedroomArea	OFF
2017-01-15	01:42:06.540302	BedroomArea	ON
2017-01-15	01:42:07.661849	BedroomArea	OFF
2017-01-15	01:42:09.374840	BedroomABed	OFF
2017-01-15	01:42:12.753318	BedroomABed	ON
2017-01-15	01:42:17.816612	BedroomABed	OFF
2017-01-15	01:42:19.689362	BedroomABed	ON
2017-01-15	01:42:21.377868	BedroomABed	OFF
2017-01-15	01:42:22.689620	BedroomABed	ON
2017-01-15	01:42:25.694993	BedroomABed	OFF
2017-01-15	01:42:27.375992	BedroomABed	ON
2017-01-15	01:42:28.503550	BedroomABed	OFF
2017-01-15	01:42:30.190984	BedroomABed	ON
2017-01-15	01:42:31.316498	BedroomABed	OFF
2017-01-15	01:42:34.876739	BedroomABed	ON
2017-01-15	01:42:39.159838	BedroomArea	ON
2017-01-15	01:42:40.284198	BedroomArea	OFF
2017-01-15	01:42:40.872715	BedroomABed	OFF
2017-01-15	01:42:41.031511	BedroomArea	ON
2017-01-15	01:42:42.159502	BedroomArea	OFF
2017-01-15	01:42:42.718525	BedroomArea	ON
2017-01-15	01:42:43.685847	BedroomABed	ON
2017-01-15	01:42:43.841324	BedroomArea	OFF
2017-01-15	01:42:46.660048	BedroomArea	ON
2017-01-15	01:42:47.248117	BedroomABed	OFF
2017-01-15	01:42:47.807461	BedroomABed	ON
2017-01-15	01:42:48.939210	BedroomABed	OFF
2017-01-15	01:42:49.659054	BedroomArea	OFF
2017-01-15	01:42:50.409987	BedroomArea	ON
2017-01-15	01:42:53.597111	BedroomArea	OFF
2017-01-15	01:42:55.284024	BedroomArea	ON
2017-01-15	01:42:56.409049	BedroomArea	OFF
2017-01-15	01:43:04.213730	BedroomADoor	ON
2017-01-15	01:43:05.342034	BedroomADoor	OFF

Situational Depression

2016-12-21	21:15:37.325084	BedroomABed	ON
2016-12-21	21:15:38.447628	BedroomABed	OFF
2016-12-21	21:15:39.384520	BedroomABed	ON
2016-12-21	21:15:42.327244	BedroomArea	ON
2016-12-21	21:15:43.511288	BedroomABed	OFF
2016-12-21	21:15:44.387634	BedroomArea	OFF
2016-12-21	21:15:45.198302	BedroomABed	ON
2016-12-21	21:15:45.515307	BedroomArea	ON
2016-12-21	21:15:46.638648	BedroomArea	OFF
2016-12-21	21:15:48.200680	BedroomABed	OFF
2016-12-21	21:15:54.947951	BedroomABed	ON
2016-12-21	21:15:56.070050	BedroomABed	OFF
2016-12-21	21:15:56.820542	BedroomABed	ON
2016-12-21	21:15:59.009541	BedroomArea	ON
2016-12-21	21:16:01.447841	BedroomArea	OFF
2016-12-21	21:16:02.072916	BedroomABed	OFF
2016-12-21	21:16:03.572897	BedroomABed	ON
2016-12-21	21:16:04.263123	BedroomArea	ON
2016-12-21	21:16:05.949805	BedroomArea	OFF
2016-12-21	21:16:06.573182	BedroomABed	OFF
2016-12-21	21:16:12.754173	BedroomABed	ON
2016-12-21	21:16:13.881495	BedroomABed	OFF
2016-12-21	21:16:14.195133	BedroomArea	ON
2016-12-21	21:16:15.324969	BedroomArea	OFF
2016-12-21	21:16:18.379555	BedroomABed	ON
2016-12-21	21:16:19.508455	BedroomABed	OFF
2016-12-21	21:16:20.066800	BedroomABed	ON
2016-12-21	21:16:22.317955	BedroomABed	OFF
2016-12-21	21:16:24.698947	BedroomArea	ON
2016-12-21	21:16:24.754478	BedroomABed	ON
2016-12-21	21:16:25.823415	BedroomArea	OFF
2016-12-21	21:16:27.000100	BedroomArea	OFF



Emerging Themes as New Discoveries

Themes	Characteristics
Room Usage	Wandering: Macro, Micro, Specific Room
Repeated Behavior	Kitchen Sink, Refrigerator, Door
Time Compare (%)	Rest vs. Activity Gap in sensor activations
Walking Speed via Ambient Sensors Only	Night time To bathroom and position of origin



Emerging Themes Continued

Themes	Characteristics
Sensor Activation Combos	Area sensor, <u>solo</u> Direct sensor, <u>solo</u> Time & length of solo activations
Bookends	Abnormal <u>between</u> normal patterns
On-ramp and Off-ramp Data (Transitions)	Rest and Sleep Bathroom usage Kitchen usage



Implications

Research	<p>Lots of LIMITATIONS! Method needs further developed May improve machine learning accuracy</p>
Education	<p>Nurses and future smart technologies</p>
Clinical Practice	<p>May extend reach of nurse Expansion of nursing informatics practice</p>
Health Policy	<p>Privacy concerns</p>



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QUESTIONS AND CONTACT INFO

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